

Emotion's Effect on Reasoning with Quantifiers

Honors Research Thesis

Presented in partial fulfillment of the requirements for graduation *with honors research distinction* in
Psychology in the undergraduate colleges of The Ohio State University

By

Bethany Lavins

The Ohio State University

May 2011

Project Advisors: Dr. Jennifer Kaminski and Dr. Vladimir Sloutsky, Department of Psychology

Abstract

In making informed and educated decisions, logical reasoning is crucial for decision makers and people in everyday life, yet research has shown that people often consistently and systematically fail to reason logically (Wason & Johnson-Laird, 1972). Contextual factors such as biases, existing beliefs, motivation and emotion have also been shown to have effects on cognition and reasoning (e.g., Blanchette, 2006; Blanchette & Richards, 2004; Ditto & Lopez, 1992; Kunda, 1990; Markovits & Nantel, 1989). The present study examined the impact reading about an emotionally valenced topic (e.g., abortion, gay rights) would have on a person's ability to reach a logical conclusion. It also explored the effect that emotional sentences vs. neutral sentences had on the interpretation of different quantifiers, in particular, whether participants were more accurate reasoning about quantifiers presented through emotionally neutral as opposed to emotionally valenced topics. In Experiment 1, participants read short, emotional or neutral paragraphs, and were asked to reason about the information presented in the paragraphs by responding to logical reasoning questions. Experiment 2 tested the participants' interpretation of the quantifiers *all*, *some*, *no* and *some...are not* when encountered in simple sentences about either emotional or neutral topics. Results from Experiment 1 indicated that participants were not significantly more accurate in responding to questions involving logical reasoning when the topic was neutral as opposed to emotional. Further, Experiment 2 did not find a significant effect of emotion; however, there were significant differences in interpretation as a function of the quantifier used. While results did not support our hypothesis, they suggest future areas to explore the effects of emotion and quantifiers in reasoning.

Introduction

The ability to reason logically is critical for decision makers and people in everyday life and involves the way we use given knowledge and facts to reach a conclusion. Its application is of crucial importance for advances in the sciences and mathematics, as the scientific method relies heavily on deductive reasoning (a type of logical reasoning in which a conclusion is derived from a premise) and reasoning plays a strong role in a person's ability to make informed, educated and accurate decisions.

Daily functioning and the ability to make important life decisions depend on the person's ability to accurately understand a situation, acknowledge their subjective interpretation of the situation, and reach a logical conclusion based on this supporting knowledge. However, research has consistently shown that people fail to reason logically, and they do so in systematic ways (Wason & Johnson-Laird, 1972). For example, two of the most common errors are mistakes in interpretation and mistakes in combination. These are caused by probabilistic inference, a situation in which a person assumes that items which share a common trait are likely to be the same, and items that lack common traits are not likely to be the same (Wason & Johnson-Laird, 1972). A personal awareness of our susceptibility to judgment errors, therefore, has the potential to reduce at least one component contributing to such mistakes.

Logical reasoning is commonly assessed by evaluating a person's ability to employ deductive reasoning. Deductive reasoning is defined as a closed system in which an individual derives conclusions from preexisting premises and judges truthfulness of a statement through normative logic (e.g., *All dogs are black. Tucker is a dog. Therefore, Tucker is black*) (Blanchette, 2006). This differs from inductive reasoning, in which an individual generalizes from a specific assumption (e.g., *All the birds I have seen can fly, so all birds can fly*).

Deductive reasoning can also involve quantifiers. Quantifiers are words that indicate a quantity, such as some, all, and none. In particular, there are different types of quantifiers such as first-order quantifiers: all, some or at least, and higher order quantifiers: "more than half," or "an even number of"

(Szymanik & Zająkowski, 2009). Quantifiers can be used to suggest the plausibility of a situation. For example, in light of the statement, “*All* students in Solon had Spring Break the week of May 15,” it would follow that if a student was from Solon, they were not on Spring Break May 12.

Individual quantifiers, such as *all* versus *some* may produce a differential impact on a person’s ability to reason logically. For example, one study found that participants tended to reach the correct conclusion more often when the quantifiers *all* or *none* were used, and made more mistakes when statements included the quantifiers *some* and *some....are not*. (Bara, Bucciarelli & Johnson-Laird, 1995). Other research exploring the impact of substituting different quantifiers has also been conducted, however most studies tend to focus on the same four quantifiers: *all*, *some*, *none*, and *some...are not*. For example, research by Bara et al. (1995), Dickstein (1981) and Roberts, Newstead and Griggs (2001), all explored the effect of these four quantifiers in syllogistic reasoning tasks.

Research has also found that people may interpret quantifiers differently based on how they are presented. For example, one study found that categorical syllogisms, arguments with two premises and a conclusion, tend to elicit different interpretations of quantifiers than simple inference tasks in which subjects have to decide which quantifier follows from a single premise (Roberts et al., 2001). The study attempted to outline strategies which led to misinterpretation and subsequent inaccurate conclusions, and evaluate predictions for when these strategies would be used (Roberts et al., 2001). They found that an error in conversion, called reversible interpretation, was less likely to occur when the participant was completing simple inference tasks as opposed to syllogistic reasoning tasks (Roberts et al., 2001). They suggested that this may be a result of the lower cognitive load demanded by inference as opposed to syllogistic tasks (Roberts et al., 2001). Thus, the difficulty of the reasoning task, such as an inference task versus a categorical syllogism task, can affect the strategy the participant uses when interpreting quantifiers, ultimately influencing their success or failure at the task. These findings, along with those from the Bara et al. (1995) study, not only highlight the important role quantifiers play in interpretation,

but suggest that the type of task in which the quantifiers are presented may also influence interpretation as well.

Superficial Influences

Along with quantifiers, numerous other factors have been identified which can contribute to errors in reasoning. For instance, some research has pointed to how even superficial factors, such as the manner or presentation of information, can interact with the characteristics of the participant to influence their ability to reason. Research by Reyna, Nelson, Han and Dieckmann (2009) found that people who display low numeracy (reasoning with numbers or mathematical concepts) may be more subject to making errors than those individuals displaying high numeracy, based on the format in which the information is presented. Their review of the current health numeracy literature found that participants who scored low in numeracy tended to make more judgment errors based on other extraneous factors, such as whether the information was presented in frequencies or percentages, and were also more influenced by the effects of mood and emotion (Reyna et al., 2009). For example, a study by Schwartz et al. (1997) found that when women were presented with risk reduction information concerning breast cancer, those who scored higher in numeracy were better able to correctly interpret and use the data to adjust their own personal risk estimates, regardless of the format it was presented in (Reyna et al., 2009).

Content and Context Effects

More specifically, the context of the situation has been shown to have a significant influence on a person's ability to reason. One type of context that has been explored concerns the familiarity of the information. Research testing math abilities of seventh and eighth grade students found that the students had greater difficulty with questions concerning speed and scaling rates when the information was presented in an unfamiliar context (Heller, Ahlgren, Post, Behr & Lesh, 1989). Students tended to perform worse on missing-value problems than on numerical comparison and directional problems which they were more familiar to using in class (Heller et al., 1989).

Different contexts can also influence reasoning for other types of tasks as well. Research by (Nakamichi, 2006) found that children performed better on a four card selection task when their mother stated the premises than when the child stated the premise. They also found that performance improved when the task was familiar or contained empirical premises known to the participant, as opposed to an unfamiliar task containing counterfactual information (Nakamichi, 2006). This research suggests that a particular format for presenting the information can increase performance on reasoning tasks, and that increased familiarity with the information can help improve reasoning as well.

Another task utilizing the Wason card task also supported the idea that contexts play a role in logical reasoning, particularly that people tend to reason more accurately with familiar than abstract contexts. The Wason four-card test is a selection task which tests conditional reasoning through an implication rule, which usual in the form 'If p then q' (Griggs & Cox, 1982). Participants, after being given the rule, are then presented with four cards and then must decide which cards are necessary to turn over in order to find out if the rule is true or false (Griggs & Cox, 1982). For example, if the rule was, 'If there is a vowel on one side of the card, then there is an even number on the other side,' and the four cards were labeled A, 4, D and 7, the correct answer would be A and 7 (e.g., If A then 7) (Griggs & Cox, 1982). In an experiment by Griggs and Cox (1982), subjects were given two problems to solve, one thematic problem and one abstract problem. The thematic problem concerned the "drinking-age problem" and asked the reader to imagine that they were a police officer carrying out their job with respect to the problem and the rule (Griggs & Cox, 1982). The abstract problem simply laid out the rule without reference to a familiar context (Griggs & Cox, 1982). Their results supported the idea that familiar contexts facilitate reasoning; participants reached the correct conclusion 73% of the time for the "drinking-age problem," yet none were able to correctly complete the abstract problem, regardless of which problem was presented first (Griggs & Cox, 1982).

In order to further examine the mechanisms acting in the (Griggs & Cox, 1982).experiment, (Pollard & Evans, 1987) expanded upon their research to see if they could isolate the context effect,

independent of the content of the problem. They modeled their design after Griggs experiment, but instead of just one perspective for the “drinking-age problem,” that of the policeman, there were four possible perspectives: the policeman condition, a security condition, a beer condition with a non-legal context, and the abstract condition (Pollard & Evans, 1987). While their findings replicated those of (Griggs & Cox, 1982), different conditions did not produce significantly more logically valid conclusions, leading them to conclude that both the content and context were important in increasing correct responses (Pollard & Evans, 1987). They further explored this content versus context problem in Experiment 2, where participants were given a rule either phrased in terms of age and beer, or numbers and letters, and asked to evaluate cards based on the rule. They found that the alcoholic drinks and age content alone did not facilitate the task, suggesting that both the specific scenario used by Griggs and the content were necessary to produce his results (Pollard & Evans, 1987).

However, while Pollard and Evans’ (1987) research did not isolate the importance of either content or context alone, there is some evidence that the context may be more important than the content. In another experiment, Griggs manipulated the order of presentation of two different card problems; an apparel problem and a “drinking-age problem.” His results found that participants performed significantly better, a 75% solution rate, when presented with the “drinking-age problem” first, as opposed to the apparel problem first, a 25% solution rate (Griggs & Cox, 1982). This may suggest that certain contexts, in this case the “drinking age problem,” may have a stronger influence on reasoning than others, regardless of the content presented, as participants performed better when they received the “drinking-age problem” first (Griggs & Cox, 1982). Overall, these two experiments suggest that both content and context of the situation can influence reasoning, specifically, familiarity of the context tends to improve reasoning ability.

While the above research suggests that the familiarity of the context may have a stronger role than content in reasoning, content still has a significant impact, particularly when it concerns information about which we hold strong beliefs. A person’s familiarity with the information is also linked to their

preexisting beliefs and biases concerning it. Research has suggested that these preexisting beliefs can have a significant impact on a person's reasoning as well. For example, information that is inconsistent with a person's beliefs (e.g., from an emotionally polarizing topic) will be examined more critically and with greater scrutiny than information that is consistent with one's beliefs (Ditto & Lopez, 1992). While it would seem that greater scrutiny of contradicting information would lead to more logical conclusions, because the information is inconsistent with existing beliefs, reading it may activate other cognitive processes which counteract normal decision making processes. For example, the participant's motivation to have their beliefs confirmed (confirmation bias) may lead them to actively seek to undermine contradictory information, which is why they examine it with greater scrutiny, looking for flaws (Ditto & Lopez, 1992). This may cause them to disregard relevant information and hence lead them to an illogical conclusion. Therefore, the significance of the content of the information presented to the participant, and whether it confirms or conflicts with their beliefs, has the potential to influence reasoning.

Further research on the effects of belief biases and attitude polarization in reasoning has also explored participants' ability to examine critically the relevant empirical evidence on issues for which they held strong opinions, particularly with respect to the effect of confirmation bias (Lord, Ross & Lepper, 1979). Confirmation bias is described as, "a tendency to look for confirming evidence to support the hypothesis, rather than look for disconfirming evidence to refute it" (Croskerry, 2002). This is a common error that often leads an individual to disregard relevant information, thereby hindering their ability to draw the most logical conclusions. In the Lord et al. (1979) experiment, students who were for and against the death penalty were exposed to two studies that either supported or discounted their existing beliefs. The results supported the authors' hypotheses, in that students rated the statements confirming their personal beliefs as more convincing and probable; results also indicated an increase in attitude polarization for both proponents and opponents (Lord et al., 1979).

Likewise, research has also suggested that people, when reasoning about information for which they hold beliefs, will employ cognitive strategies consistent with the production of a desired outcome or

a conclusion consistent with their beliefs. Similar to the drive to confirm existing beliefs, when motivated to produce a certain desired outcome, participants are more likely to rely on biased cognitive processes, such as looking for hypothesis-confirming evidence and ignoring hypothesis-disconfirming evidence, whereas those motivated to be accurate will rely on strategies considered more appropriate for evaluating the problem (Kunda, 1990). For example, Moore, Tanlu and Bazerman (2010) reported that participants were more likely to conclude that the accounting behind a firm's financial reports complied with Generally Accepted Accounting Principles (GAAP) if they worked for the company, as opposed to an outside agency. Simply making participants employees of the company, as opposed to outsiders, biased their evaluation in favor of the company, and led them to a conclusion (the financial reports complied with GAAP) favoring the desired outcome – they wanted their company to pass and succeed. This suggests that when motivated to reach a certain outcome, participants may selectively (whether consciously or unconsciously) employ cognitive strategies which increase the likelihood that they will reach a conclusion consistent with their favored conclusion (Moore et al., 2010).

In an application more specific to logical reasoning, belief in the validity of a statement has also been found to have a significant impact on a person's ability to draw logical conclusions (Markovits & Nantel, 1989). Findings from a study that examined college students' ability to complete reasoning tasks on either neutral or belief problems found a significant belief-bias effect, or the influence of existing beliefs, independent of the participants' abstract reasoning ability (Markovits & Nantel, 1989). In the neutral task, the premise was believable, while in the problem task, the major premise was either untrue or unbelievable. Results showed that the participants' error rate increased by 30% when they were asked to reason about the belief-biased or untrue premises (Markovits & Nantel, 1989). When asked to choose their own conclusion, the error rate increased by 30% as compared to a 63% increase in error rate when they had to create their own conclusion (Markovits & Nantel, 1989). These results suggest that people may be more prone to make mistakes in reasoning when the statement is invalid or believed to be invalid,

and that the manner in which they are asked to give their response can have a significant influence on reasoning as well.

Emotion

Belief in the validity of a statement and the ability to reason are also directly connected to emotion. As shown in the Lord et al. (1979) study where participants' beliefs became more polarized when exposed to arguments disconfirming their beliefs, certain information or topics can elicit emotions in participants, holding the potential to interfere with and bias reasoning as well.

General research surrounding emotion has pointed to numerous effects of emotional state on decision making capabilities, judgments and reasoning (Kunda, 1990). The experience associated with some emotions, such as anger and contentment, can lead to feelings of certainty, while emotions such as surprise, fear and worry can lead individuals to feel uncertain or unsure about their current situation (Tiedens & Linton, 2001). These emotional states, then, can impact their subsequent decision making. For example, in a recent study, researchers found that participants induced to feel emotions associated with certainty were more likely to rely on heuristic cues (superficial cues like the expertise of the source) and be more certain about their judgments when answering questions, than those induced to feel emotions associated with uncertainty (Tiedens & Linton, 2001). Because reliance on heuristics can cause a participant to disregard important information, this suggests that eliciting emotions associated with certainty can potentially lead to illogical reasoning.

More specifically, further research has focused on how emotions may influence the way in which a person reasons with the information given them. Research by Kaufman (1999) has found that extremes in emotional arousal can lead to a state of bounded rationality, defined as a person's, "...tendency to call off a search once something is found" (Croskerry, 2002; Kunda, 1990). This is significant for reasoning ability in that individuals in a state of emotionally aroused bounded rationality may fail to consider other important information presented once they have reviewed information that satisfies their own interest

(Croskerry, 2002). Thus, when in a heightened emotional state, a person may cease to process information effectively, and thus be unable to reach a logical conclusion.

While most of the above studies have implied a negative role for emotions in reasoning, some research does suggest that emotion may in fact be a crucial component in rational decision making, not impairing but rather enhancing reasoning abilities. Damasio's somatic marker hypothesis suggests that 'marker' signals (such as introducing a bias when making a choice) influence the way in which we process and respond to stimuli (Damasio, Everitt & Bishop, 1996). His work suggests that these 'somatic marker' signals are regulated in areas of the brain associated with emotional processing, and can help to modulate decision making in complex and uncertain situations (Dunn, Dalgleish & Lawrence, 2006).

Research by Bechara, Damasio, A., Damasio, H. and Anderson (1994), and Bechara, Tranel, Damasio, H. and Damasio, A. (1996) on the Iowa gambling task supported this theory, finding a correlation between successful performance on the task and the development of somatic marker signals, which were measured by the magnitude of anticipatory skin conductance responses in participants (Dunn et al., 2006). Emotions, therefore, may be crucial in guiding the decision making process, rather than hindering its ability to function efficiently. Damasio's theory suggests that developing these internal 'marker' signals can help guide us to the correct response, and that emotionality is a rational tool employed by the mind to lead us to the most optimal decision. Thus the study of emotion may reveal both positive and negative consequences of reasoning processes in concert with other situational factors.

Emotion can also affect other aspects of cognition and reasoning as well. For example, emotionally-laden words have been shown to enhance free recall of related words and possible contextual information (Doerksen & Shimauro, 2001). However, emotional states also appear to have a largely negative impact on critical thinking and logical reasoning (Blanchette & Richards, 2004). That is, people are more likely to endorse a logical fallacy when reasoning in emotional contexts compared to neutral contexts (Blanchette & Richards, 2004). Likewise, in another study, participants were less accurate in

conditional reasoning tasks involving emotional stimuli than similar tasks involving neutral stimuli (Blanchette, 2006). However, emotional and neutral conditional statements were interpreted similarly (Blanchette, 2006). These findings suggest that emotion does not necessarily affect interpretation of conditional statements, but may affect subsequent reasoning about such statements.

With the exception of the studies noted above, (e.g., Blanchette, 2006; Blanchette & Richards, 2004), little research has examined the effects of emotion on other aspects of logical reasoning. While Blanchette's (2006) study focused on the impact of short emotional phrases, little is known about logical reasoning regarding specific topics or contexts.

Thus, in light of the existing research on context, as well as beliefs, emotion and quantifiers, the current study sought to explore the effect of emotion on logical reasoning in two specific areas: How we reason about information presented in an emotional or neutral paragraph and how we interpret the quantifiers *all*, *some*, *no* and *some...are not* when presented in either emotional or neutral sentences.

To examine this, the current study employed a Calibration Study and two experiments to explore the effects of emotional processing on logical reasoning and interpretation of quantifiers. In our Calibration Study, we presented students with emotionally valenced and neutral topics, and asked them to rate their opinion on the topic. These responses were then used to determine which scenarios to use in Experiment 1. Experiment 1 examined the effects of emotional context on logical reasoning by presenting participants with emotionally charged and neutral paragraphs, and evaluated their ability to respond to questions grounded in logical premises. Experiment 2 investigated the participant's ability to interpret the quantifiers *all*, *some*, *no* and *some...are not* when encountered in simple sentences with either emotional or neutral topics.

We recognized that the topics we considered might be emotional for some participants, but not for others. While an attempt to control for such bias was done by determining the most polarizing topics for students, individual differences were still possible. To address these differences, numerous emotional and neutral situations were used throughout the study, and participants were asked at the end of the study

to rate how emotional a particular topic was for them. This independent rating was then taken into account when analyzing the data.

We expected that significant deviations in correct responses to emotionally charged verses neutral paragraphs or sentences would indicate an emotional influence. Likewise, differences in responses as a function of the quantifier used may also provide insight into the reasoning process, particularly if emotion is shown to interact with the quantifier type. This may suggest that different quantifiers can produce more errors in reasoning either in conjunction with or isolation from emotion.

As emotional contexts have already been shown to have the potential to bias and negatively influence logical reasoning, we hypothesized that the presentation of emotional topics could have the same effect when participants were asked to interpret different quantifiers. Therefore, we expected participants to perform worse in Experiment 1 on logical reasoning tasks when the topic was emotional. We also expected that participants would make more errors when interpreting quantifiers in Experiment 2 when they were presented in emotional as opposed to neutral sentences.

Methods and Planned Analyses

Calibration Experiment

The purpose of the Calibration Experiment was to determine the emotional and neutral scenarios to be used in Experiment 1. To do this, participants were presented with 27, 16 that were considered emotional and 11 that we considered neutral, and asked to rate the strength of their opinions and those of other college students for each issue.

Method

Sample and Participant Selection

Participants were 25 undergraduate students at the Ohio State University enrolled in Psychology 100, who received course credit for their participation. The average age was 20.96 (SD = 2.10), and ranged from 18 to 28. One participant declined to report their age and gender was not recorded.

Design and Materials

Participants responded to a 27 item self-report questionnaire (see Appendix A). Topics included: (1) Emotional topics: Politics, healthcare, homosexuality/gay marriage (e.g., “Don’t ask, don’t tell”), abortion (e.g., stem cell research), environmental activism (e.g., global warming), gun control, immigration, affirmative action, capital punishment, drugs (e.g., legalizing marijuana), alcohol (e.g., drinking age), whether creationism should be taught in public schools/prayer in school, cloning/genetic engineering (e.g., GMOs), alcohol abuse/laws (e.g., lowering the drinking age), torture, euthanasia, obesity epidemic and (2) Neutral topics: Heating and air conditioning costs, the weather, the best spring break destination, tourism in Iceland, the price of groceries, coffee consumption, summer internship opportunities, hairstyles, favorite president, and the legal age to marry, presidential discretionary spending (e.g., Michelle Obama).

Participants were then asked to respond to two questions: “How strong are YOUR opinions on this topic?,” and, “How strong do you believe OTHER college students’ opinions are on this topic?.” They rated their responses on a 5 point scale, with 1 = “Not strong at all. I have no opinions on this topic,” and 5 = “Very strong. I have passionate opinions on this topic.”

Procedure

Participants were tested individually, with the scenarios and questions presented with a pencil and paper questionnaire on which they indicated their response by circling their choice, and proceeded in a self-paced manner. Responses were compiled by a research assistant.

Results

The average emotional rating for each presented topic was calculated for the questions, “How strong are YOUR opinions on this topic?,” and, “How strong do you believe OTHER college students opinions are on this topic?.” The most emotional topic was abortion ($M = 4.04$, $SD = 1.08$) and the least emotional was tourism in Iceland ($M = 1.64$, $SD = 0.98$). Mean emotional scores were out of a maximum score of 5, with 1 indicating no strong opinions and 5 indicating passionate opinions on the topic.

From those results, we selected three of the most emotional topics: Abortion ($M = 4.04$, $SD = 1.08$), gay marriage ($M = 3.96$, $SD = 1.28$), and healthcare ($M = 3.6$, $SD = 1.20$) and three of the least emotional topics: The legal age to marry ($M = 2.00$, $SD = 1.10$), the best/worst hairstyles ($M = 2.08$, $SD = 1.13$) and the best spring break destinations (Florida vs. Cancun) ($M = 2.28$, $SD = 1.25$) to be used in Experiment 1. Overall, emotional topics obtained a mean rating of 3.45 ($SD = 0.35$) and neutral statements 2.57 ($SD = 0.65$).

Experiment 1 – Logical Reasoning

The purpose of Experiment 1 was to determine the effect of emotional context on logical reasoning after reading a heightened emotional or neutral paragraph. Participants were presented with six different scenarios (passages/stories), three emotionally charged and three neutral. After reading each passage, participants were given five test questions. Three of the questions tested basic recall, and two tested logical reasoning. After the experiment, participants were asked to rate how emotional each paragraph was for them and then were free to leave.

Method

Sample and Participant Selection

Participants were 37 undergraduate students at the Ohio State University enrolled in Psychology 100, who received course credit for their participation. There were 15 women and 22 males. The average age was 21.43 ($SD = 6.37$), and ranged from 18 to 50.

Design and Materials

Scenarios and questions were presented on desk top computers using SuperLab Pro, with a template created through Microsoft Powerpoint 2007.

The experiment format was an introduction and preliminary instructions, followed by six paragraphs, three neutral and three emotional, which were presented in a randomized order. All had the same logical structure. The topics for these paragraphs were selected from an initial set of twenty-seven submitted to a separate group of individuals in the Calibration Experiment. Topics were selected to maximize differences, with three of the most emotional and three of the least emotional selected for inclusion. On average, the selected emotional topics obtained a rating of 3.45 ($SD = 0.35$) and the neutral statements 2.57 ($SD = 0.65$) out of a possible maximum score of 5. Before each new paragraph, the instructions were presented again to ensure the participant understood what was being asked. The study ended with six follow-up questions.

Participants read the short emotional or neutral paragraphs, and were asked to reason about the information presented in the paragraphs by responding to logical reasoning and recall questions. Emotional topics were: Same-sex marriage, abortion and healthcare. Neutral topics were: The legal age to marry, the best/worst hairstyles and the best spring break destination (Florida vs. Cancun). The full length paragraphs used for each topic are included in Appendix B.

All paragraphs attempted to follow the same general pattern of information presentation. Each was approximately three-hundred and fifty words in the following outline:

1. Introduce Topic - 1 sentence
2. Give context – 1 sentence
3. Give details – 2 sentences
4. Give an opinionated perspective 2 - sentences
5. Statement with quantifier *some*
6. Give example – 1 sentence
7. Give more commentary – 1 sentences
8. End - 1 sentence

Within each paragraph was a key quantifier phrase which would be tied to the questions testing logical reasoning. These key phrases indicated that *some* members of the population behaved one way, but not all did. Each key quantifier phrase utilized the same general format, presenting the participant with a statement relevant to some but not all the members of a population.

Example quantifier statement for The Best and Worst Hairstyles (neutral): “**Some** activists opposed to regulation of hairstyles believe that hair nets and hats worn by employees to prevent contamination of food infringe on their first amendment rights, and that any such apparatus should be banned.”

Before each paragraph, the instructions were repeated to remind the participant of the task. Instructions given for each paragraph were as follows:

Please answer the following questions. Read the questions carefully and base your answers only on the information that you read in the passage, not on any prior knowledge or belief.

Follow up questions used the same structure for each scenario. Each scenario was followed by five questions in the following format:

1. The paragraph was about ____? (True or False)
2. Which of the following was/was not stated in the passage? (multiple choice)
3. **According to the passage ____? (Yes or No)**
4. In the passage, what was/ was not mentioned, ... (multiple choice)
5. **According to the passage ____? (Yes or No)**

Of the five questions, three were basic recall questions (questions 1, 2 and 4 above) and two were logical reasoning questions (question 3 and question 5). Questions were always presented in the same order: Recall, recall, logic, recall, logic. The third and fifth questions (logic), bolded above, were linked to the specific “quantifier” statement in each passage (utilizing the word *some*). These logic questions tested both recall of the quantifier and reasoning about the quantifier. We used the responses to the logic questions to assess the participants’ ability to reason. Examples of emotional and neutral questions can be found in Appendix C.

Following the experiment, we asked the participants to respond to the same question used in the Calibration Experiment, “How strong are YOUR opinions on this topic?,” for each of the six scenarios they were presented with in the experiment. They rated their response on a 5 point scale, from 1 = “Not

strong at all. I have no opinions on this topic,” to 5 = “Very strong. I have passionate opinions on this topic.” The order of questions was randomized.

Procedure

The participants were tested individually, with the scenarios and questions presented on a computer screen under self-paced conditions. Responses were recorded by the computer and later compiled by a researcher.

Students were instructed that they should read each scenario and would then be asked to answer some questions following the passage. They were told their answers should be based only on information read in the passage and not on any prior knowledge or beliefs. Following each paragraph, the students answered five questions related to the scenario for which they were asked to recall information discussed in the passage.

The order of presentation of paragraphs was randomized for each trial. Individuals recorded responses by entering the appropriate number of the answers shown on the computer screen. For example:

Please answer whether this statement is true or false: 1 – True, 2 – False.

Following completion of the six scenarios, the participants were then asked to rate, on a scale of 1 to 5, the strength of their opinions on the scenarios presented in the experiment. Instructions were as follows: *For the paragraph on Abortion, please answer the question: “How strong are YOUR opinions on this topic?” using the following scale: 1 = “Not strong at all. I have no opinions on this topic,” and 5 = “Very strong. I have passionate opinions on this topic.”* The order of the follow-up questions was randomized for each trial.

Results

Statistics and Data Analyses:

Results indicated that emotional context did not have an influence on the ability to employ logically reasoning about quantifiers. The participants were not significantly more likely to choose the

logically valid answer when reasoning after reading neutral paragraphs as opposed to emotional paragraphs for logical reasoning questions.

To determine the influence of emotional contexts, the average number of correct responses to recall and logical reasoning questions for all emotional (“E”) contexts and neutral (“N”) contexts was calculated. We calculated the mean score on the quantifier questions for all “E” contexts (number of quantifier questions correct) and the mean score on the quantifier questions for all “N” contexts. The same was repeated for recall questions for both “E” and “N” contexts.

Total number of correct responses was obtained for:

- (1) All Recall Emotional
- (2) All Logical (quantifier) Emotional
- (3) All Recall Neutral
- (4) All Logical (quantifier) Neutral

We submitted the mean scores for logical reasoning to a paired sample t-test set to alpha, $\alpha = .05$, between the emotional and neutral categories, to determine if there were significant differences in accuracy on the test questions across the emotional and neutral context. Mean scores were out of a maximum 6 questions for logical reasoning, and 9 questions for recall questions. There was no significant differences between the emotional ($M = 3.84$, $SD = 1.76$) and neutral ($M = 4.03$, $SD = 1.80$) categories for logical reasoning, $t(36) = -.839$, $p = .407$. The difference was also not significant for recall questions between emotional ($M = 7.03$, $SD = 1.52$) and neutral ($M = 7.54$, $SD = 1.59$), $t(36) = -1.688$, $p = .100$.

Effect size (Cohen’s d) was calculated by subtracting the mean difference in logical reasoning scores for emotional scenarios from the mean difference in logical reasoning scores for neutral scenarios and dividing by the standard deviation. The effect size ($d = -.045$) suggested that there are no differences between emotional and neutral questions.

However, participants did perform better on recall, 81% accuracy, than on logical reasoning questions, 66% accuracy.

Results found participants rated emotional paragraphs ($M = 3.38$, $SD = 1.20$) higher than neutral ($M = 1.95$, $SD = 1.13$), $t(104) = 9.193$, $p < .0001$. Emotional ratings were out of a possible score of 5, with 1 indicating no strong opinions and 5 indicating passionate opinions on the topic.

Further analyses were carried out to examine whether participants ratings of emotion reflected ours (which were based on ratings from the Calibration Experiment). The point biserial correlation coefficient, calculated using Lowry's calculation tool, was significantly different from zero, $r_{pb} = -0.53$, $t(217) = -9.14$, $p < .0001$, confirming that participants ratings of emotionality in Experiment 1 correlated with those in the Calibration Experiment (Lowry, n.d.). This suggests that we accurately correlated emotional and neutral topics with the participants' emotional views.

There was not a significant correlation between participant ratings of emotionality and scores for each paragraph. As shown in Table 1, results were only significant for recall questions when the paragraph topic was the legal age to marry, $r(33) = -.46$, $p = .005$ or the best spring break, $r(33) = -.36$, $p = .033$. There was no correlation for logical reasoning questions and emotionality.

Table 1

Pearson Correlations Between Participant Emotional Ratings and Scores

Topic	Question Type	
	Recall	Logic
Healthcare	.14	-.03
Abortion	.26	.28
Same Sex Marriage	.14	.26
Legal Age to Marry	-.46**	-.02
Hairstyles	.33	-.05
Best Spring Break	-.36*	.11

Note. (N = 35). *Correlation is significant at the .05 level. ** Correlation is significant at the .01 level (two tailed)

The software package SPSS 18.0 (Statistical Package for the Social Sciences) was used for all t-tests, effect size and correlation analyses with the exception of the point biserial correlation coefficient, calculated using Lowry's calculation tool (Lowry, n.d.).

Experiment 2 – Interpretation of Quantifiers

The purpose of Experiment 2 was to examine whether or not the interpretation of quantifiers can be influenced by the emotionality of the statement. There are often multiple ways in which a person can respond to a statement, and their ability to employ logical reasoning often (but not necessarily always) can depend on the nature of the quantifier. For example, the statement, “*All* the dogs at OSU are black,” could reflect several possible situations which would not be valid under the statement, “*Some* of the dogs at OSU are black.” The difference depends on the quantifier used, between *all* and *some*. Thus, we specifically explored the effect that different quantifiers (such as *all*, *some*, *no* and *some...are not*) could have on the participant's ability to interpret quantifiers when the topic was either emotional or neutral. In this experiment, participants were presented with short emotional by topic, emotional by surprise or neutral sentences. For each topic there four sentences, one for each quantifier: *all*, *some*, *no* and *some...are not*. Participants were then asked to reason about the information presented in the sentences by selecting the Venn diagram(s) that did not violate the given statement. Questions were randomized through the study.

Method

Participants

Participants were 36 undergraduate students at the Ohio State University enrolled in Psychology 100, who received course credit for their participation. There were 7 women and 29 males. The average age was 18.971 (SD = 1.248), and ranged from 18 to 25.

Design and Materials

Scenarios and questions were presented on desk top computers using SuperLab Pro, with a template created through Microsoft PowerPoint 2007. Responses were written down manually on a response sheet provided to the participants by the experimenter.

The experiment format was an introduction and preliminary instructions, followed by 24 statements surrounding six different topics: Two neutral (skiers and books), two emotional by topic (abortion and gay marriage) and two emotional by surprise (Asians and French fries). These were presented in a randomized order.

All had the same logical structure. The emotional topics for the emotional by topic sentences were selected from the emotional stimuli used in Experiment 1, and the neutral and emotional surprise topics were selected to model statements found in the Bara et al. (1995) study. Participants were given instructions and asked to evaluate these emotional and neutral sentences containing quantifier by selecting the Venn diagram (s) which corresponded to their interpretation of the quantifier used in that sentence. For every topic, there were four sentences, each substituting one of the four quantifiers studied: *all*, *some*, *no* and *some...are not*.

Initial instructions were as follows:

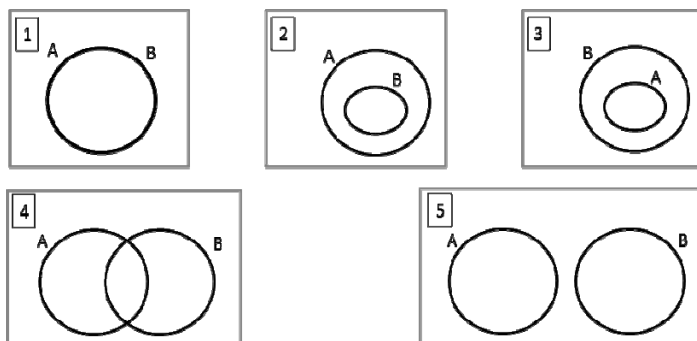
*In this experiment, you are going to read a series of short sentences. Each sentence involves two sets. You will also be shown several Venn Diagrams involving two sets. Your job is to read the sentences and then select all possible diagrams that do not violate the given sentence. Each of the possible diagrams will be numbered. To respond, write down all the numbers for the diagrams you choose. Press the space bar to proceed to the next slide. You will **not** be able to go back to the previous diagrams so please pay close attention!*

Instructions given for each sentence were as follows: All snow boarders are Shaun White fans.

Here: Set A is the set of snow boarders and Set B is the set of Shaun White fans. Choose all possibilities and write the corresponding numbers on your answer sheet.

Figure 1

Sample Venn Diagram



All sentences followed the same general pattern of information presentation. Set A was always a noun, and Set B was a characteristic describing the noun. Each sentence was approximately eight words in length (see Appendix D for the full length sentences). Each topic (i.e. Shaun White, books, abortion) was presented in four different variations for each of the quantifiers (*all*, *some*, *no* and *some...are not*).

9. All A are B.
10. Some A are B.
11. No A are B.
12. Some A are not B.

Participants read the short, emotional (topic), emotional (surprise) or neutral sentences, and were asked to interpret the information presented in the sentences by selecting the Venn diagram (s) that did not violate the given statement. There were five different Venn diagram possibilities: $A = B$, A includes all of B, B includes all of A, A and B overlap, and A is separate from B (see Figure 1 for the Venn diagram). The same Venn diagram and instructions were used for every sentence. Venn diagrams were numbered 1 through 5.

Procedure

The participants were tested individually, with the Venn diagrams and sentences presented on a computer screen under self-paced conditions. Responses were recorded by the participant on a response page and were later compiled by a researcher.

Participants were presented with an introduction explaining the nature of the experiment, and given instructions on how to answer the questions before each sentence. In each condition, the participant was presented with a topic sentence, a description of what the two subsets were (For Example: All snowboarders are Shaun White Fans, Subset A: snowboarders, Subset B: Shaun White fans), and a Venn diagram. The order of presentation for the 24 different sentences was randomized for each trial.

Results

The software package SPSS 18.0 was used for all statistical analyses with the exception of chi-square testing of emotion type and interpretation errors, which was conducted using Preacher's

calculation tool (Preacher, 2001). One participant did not complete the entire experiment and that data was eliminated from analysis.

Overall, participants did not perform better on questions for neutral as opposed to emotional sentences. As shown in Table 2, while participants performed better for questions utilizing the quantifiers *no* and *all*, the number of correct responses did not differ across emotional categories.

Table 2

Correct Responses by Question Type - Experiment 2

Quantifier Type	Emotional Condition		
	Emotion Topic	Emotion Surprise	Neutral
	M (SD)	M (SD)	M (SD)
All	1.09 (.89)	1.23 (.88)	1.14 (-.88)
Some...are not	0.03 (.17)	- (-)	0.03 (.17)
No	1.83 (.51)	1.83 (-.51)	1.77 (.55)
Some	0.09 (.37)	0.06 (.34)	0.06 (.34)

Note. Responses were out of a possible 2 questions for each category. Emotional Surprise sentences for *some...are not* had no correct responses.

There were no differences in errors across question types. A χ^2 test comparing errors types within levels of emotion type was conducted. Groups were created to categorize the most frequent types of mistakes which resulted in interpretation errors, either in the form of omissions (e.g., If the answer for *All* was 1 and 3 and they only responded 1, then 3 was considered omitted) or inclusions (e.g., Adding an extra number). The results of the χ^2 tests showed that the types of errors made did not differ across the different emotional manipulations, all $ps > .27$.

However, while the types of errors did not differ across different emotional manipulations, there were still notable differences in response errors for individual quantifiers. For the quantifier questions involving *some*, the most common mistake was failing to include all the possible solutions; 91% of participants omitted solution 1 ($A = B$) and 79% omitted solution 3 (A and B overlap). For the quantifier questions on *some...are not*, the most common error was omitting solution 5, 84% (A is separate from B). There were very few errors for the quantifier questions concerning *no*, however, when mistakes were made, the most common error was including solution 1, 6%. The most common errors for *all* were

omitting solutions 1, 19%, and solution 3, 21%. Correct answers for sentences were as follows: *all*: 1 and 3; *no*: 5; *some*: 1, 2, 3 and 4; *some...are not*: 2, 4 and 5 (see Figure 1 for Venn diagram).

A repeated measures ANOVA was conducted to assess the effects of emotion, quantifier, and the interaction of the two factors on accuracy. Mauchly's Test of Sphericity was significant for both emotion, $\chi^2(2) = 11.95$, $p < .01$, and quantifier type, $\chi^2(5) = 64.94$, $p < .001$ so the Greenhouse-Geisser correction on degrees of freedom was used when assessing F-values. The main effect of emotion was non-significant, $F(1.53, 52.16) = .32$, $p = .67$, as was the emotion-by-quantifier interaction, $F(3.25, 110.61) = .83$, $p = .49$. However, the main effect of quantifier type did reach statistical significance, $F(1.91, 64.98) = 107.73$, $p < .001$.

To further explore the significant effect of quantifier, post-hoc tests within the types of quantifier were conducted. Participants mean scores were out of a possible 6 questions correct for each quantifier. It was found the quantifier *no* ($M = 5.43$, $SD = 1.34$) was significantly different from the quantifier *some* ($M = .200$, $SD = 1.02$), $F(1, 34) = 570.61$, $p < .001$, and the quantifier *some....are not* ($M = .057$, $SD = .24$), $F(1, 34) = 203.108$, $p < .001$. Additionally, the quantifier *all* ($M = 3.46$, $SD = 2.41$) was also found to be significantly different from the quantifier *no*, $F(1, 34) = 22.35$, $p < .001$; however, this difference was much smaller in magnitude than the differences between the quantifier *no* and the quantifiers *some* and *some....are not*.

General Discussion

Our results did not support our hypothesis that the emotional context may influence a person's ability to employ logical reasoning. Participants in Experiments 1 did not perform better on logical reasoning questions following neutral as opposed to emotional paragraphs, and in Experiment 2, did not perform statistically better when asked to interpret quantifiers presented through emotionally valenced as opposed to emotionally neutral contexts.

However, our results are consistent with the findings of research by Bara et al. (1995), suggesting accuracy of interpretation was influenced by the quantifier type, in Experiment 2. In their research, Bara et al. (1995) found that participants tended to reach the correct conclusion more often for *All the A are B* and *None of the A is B*, yet tended to make more errors for statements involving *Some* and *Some...are not* (Bara et al., 1995). This is similar to our findings that participants performed better for statements which involved *all* or *no*.

Post-hoc tests for our Experiment 2 confirmed that there were significant differences in responses to questions between the quantifier *no* and quantifiers *some* and *some...are not*. We also found a significant difference between *no* and *all*, however, this difference was much smaller in magnitude than the differences between *no* and quantifiers *some* and *some...are not*, suggesting responses to questions about *all* and *no* may be more similar than those concerning *some* and *some ...are not*. Thus our results supported the conclusions reached by Bara et al. (1995), further adding to the finding that people interpret different quantifiers with different degrees of accuracy.

There is largely a dearth of information in the current research field considering the impact of emotion on logical reasoning. One exception is research by Blanchette (2006) and Blanchette and Richards (2004). Similar to our study, their research explored the accuracy of an individual's ability to reason on tasks involving emotional as opposed to neutral stimuli, as well as their propensity to endorse a logical fallacy under the mentioned conditions (Blanchette, 2006; Blanchette & Richards, 2004). Her results suggested that people are more likely to endorse a logical fallacy when they are reasoning about emotional as opposed to neutral content, and are less accurate in conditional reasoning tasks involving emotional stimuli (Blanchette, 2006; Blanchette & Richards, 2004). However, her research only considered conditional reasoning, exploring the impact of short phrases to which participants were conditioned to view emotionally.

The present study explored how emotion impacts other aspects of logical reasoning, such as interpretation with quantifiers and reasoning in paragraphs. While we did not find a significant effect for emotion in logical reasoning or interpretation of quantifiers, this does not mean that it does not exist. Other research in this area, such as Blanchette's experiments on emotion and interpretation, found very small effect sizes (Blanchette, 2006; Blanchette & Richards, 2004). Emotion may still be playing a role, albeit, it just may not have produced results as large as we expected in this particular experiment.

Another concern may be that our experiment did not correlate to actual real world situations causing emotional arousal. Reading a short paragraph or sentence may not activate the same emotional response that may be elicited in other daily situations, such as a heated (verbal) discussion about an emotional issue. Further, while self-reported data from the participants confirmed that our judgments of emotionality correlated with theirs, it is also possible that self-reports of emotion may not correlate with the participant's actual emotional state.

An additional possible factor which could have influenced our results in Experiment 1 is participant fatigue. To avoid this threat to validity, questions were presented in a pseudo-random order. However, it is still possible that the length of the paragraphs caused the participants to become tired with the study early on, and dampened their interest as well as emotional arousal when answering questions or reading paragraphs. Thus, we may have been unable capture the same cognitive processes that would be activated if the participant was alert and aroused. This is another component that could, along with other factors, account for why our experiment did not reproduce results showing the effects of emotion in other experiments.

As stated above, while our research did not capture an emotion effect for interpretation with quantifiers, this does not mean it does not exist. Future research may wish to explore other paradigms employing quantifiers which may better activate the participant's emotions. It may also explore whether a person's rating of how emotional a topic is to them affects their performance; i.e. while both our ratings

of the emotionality of a paragraph and the participants were correlated, is self-reported emotion really reflective of the participant's actual level of arousal? Possible methods for exploring this could employ the use of a combination of biofeedback measures which could be used to correlate the level of physiological arousal with specific responses to reasoning questions.

Further, the use of particular words, phrases or statements which may be seen as culturally inappropriate in one society might be used to elicit emotional responses as well. If emotions aroused by a cultural faux pas are shown to contribute to inappropriate or incorrect interpretation of quantifiers, this could have significant ramifications for diplomatic interactions between heads of state and other emissaries, emphasizing the importance of cultural competence to reduce biases and misunderstandings.

Finally, another area in which such research could be extended is in standardized testing. The current Graduate Record Examination (GRE) includes an "Analysis of an Argument Essay," in which the reader is asked to critique the argument's line of reasoning and the evidence supporting it, while suggesting ways in which the argument could be strengthened. Such an argument could possibly employ quantifiers, for example, "*All* Democracies support the principles of freedom and liberty upheld in the U.S. Constitution." Since our results from Experiment 2 showed that participants performed better when interpreting the quantifiers *all* and *no*, as opposed to *some* and *some...are not*, it is possible that students receiving an essay argument topic which requires interpretation with the quantifiers *some* and *some...are not* may score more poorly on the essay, as compared to those receiving an argument using *all* or *no*, as a result of fault in their logical reasoning. Unlike the "Analysis of an Issue Essay," the student does not receive a choice of topics here, thus it may be interesting to investigate if this has any impact on the student's subsequent performance.

Overall, these results hold a positive note for decision makers in all walks of life. By understanding that quantifiers can affect an individual's ability to reason, steps can be taken to avoid interpretation traps in the same way as avoiding biasing and framing effects.

References

- Bara, B., Bucciarelli, M. & Johnson-Laird, P. (1995). Development of syllogistic reasoning. *American Journal of Psychology*, 108 (2), 157-193.
- Bechara, A., Damásio, A., Damásio, H. & Anderson, S. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, 50 (1-3), 7-15.
- Bechara, A., Tranel, D., Damasio, A., Damasio, H. (1996). Failure to respond autonomically to anticipated future outcomes following damage to prefrontal cortex. *Cerebral Cortex*, 6, 215-225.
- Blanchette, I. (2006). The effect of emotion on interpretation and logic in a conditional reasoning task. *Memory & Cognition*, 34, 1112-1125.
- Blanchette, I. & Richards, A. (2004). Reasoning about emotional and neutral materials. Is logic affected by emotion?. *Psychological Science*, 15, 745-752.
- Croskerry, P. (2002). Achieving quality in clinical decision making: cognitive strategies and detection of bias. *Academic Emergency Medicine*, 9 (11).
- Damasio, A., Everitt, B. & Biship, D. (1996). The Somatic Marker Hypothesis and the Possible Functions of the Prefrontal Cortex [and Discussion]. *Philosophical Transactions: Biological Sciences*, 351(1346), 1413-1420.
- Dickstein, L. (1981). Conversion and possibility in syllogistic reasoning. *Bulletin of the Psychonomic Society*, 18, 229-232.
- Ditto, P. & Lopez, D. (1992). Motivated skepticism: Use of differential decision criteria for preferred and nonpreferred conclusions. *Journal of Personality and Social Psychology*, 63, 568-584.

- Doerksen, S. & Shimauro, A. (2001). Source memory enhancement for emotional words. *Emotion*, 1(1), 5-11.
- Dunn, B., Dalgleish, T. & Lawrence, A. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience & Biobehavioral Reviews*, 30 (2), 239-271.
- Griggs, R. & Cox, J. (1982). The elusive thematic-materials effect in Wason's selection task. *British Journal of Psychology*, 73 (3), 407-420.
- Heller, P., Ahlgren, A., Post, T., Behr, M. & Lesh, R. (1989). Proportional reasoning: The effect of two context variables, rate type, and problem setting. *Journal of Research in Science Teaching*, 26 (3), 205-220.
- Kaufman, B. (1999). Emotional arousal as a source of bounded rationality. *Journal of Economic Behavior & Organization*, 38, 135-144.
- Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, 108(3), 480-498.
- Lord, C., Ross, L. & Lepper, M. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology*, 37 (11), 2098-2109.
- Markovits, H. & Nantel, G. (1989). The belief-bias effect in the production and evaluation of logical conclusions. *Memory & Cognition*, 17, 11-17.
- Lowry, R. (n.d.). *VassarStats: Website for Statistical Computation*. Retrieved May 5, 2011, from <http://faculty.vassar.edu/lowry/VassarStats.html>.
- Moore, D., Tanlu, L. & Bazerman, M. (2010). Conflict of interest and the intrusion of bias. *Judgment and Decision Making*, 5, 37-53.

- Nakamichi, K. (2006). Young children's conditional reasoning on the four-cards selection task: The influence of context and experience. *Psychologia: An International Journal of Psychology in the Orient*, 47, 238-249.
- Neuman, Y., Weinstock, M. & Glasner, A. (2006). The effect of contextual factors on the judgment of informal reasoning fallacies. *The Quarterly Journal of Experimental Psychology*, 59 (2), 411-425.
- Pollard, P. & Evans, J. (1987). Content and context effects in reasoning. *American Journal of Psychology*, 100 (1), 41-60.
- Preacher, K. (2001). Calculation for the chi-square test: An interactive calculation tool for chi-square tests of goodness of fit and independence [Computer software]. Available from <http://quantpsy.org>.
- Reyna, V., Nelson, W., Han, P. & Dieckmann, N. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin*, 135, 943-973.
- Roberts, M., Newstead, S. & Griggs, R. (2001). Quantifier interpretation and syllogistic reasoning. *Thinking & Reasoning*, 7, 173-204.
- Schwartz, L., Woloshin, S., Black, W., & Welch, H. (1997). The role of numeracy in understanding the benefit of screening mammography. *Annals of Internal Medicine*, 127 (11), 966-972.
- Szymanik, J. & Zająkowski, M. (2009). Improving methodology of quantifier comprehension experiments. *Neuropsychologia*, 47, 2682-2683.
- Tiedens, L. & Linton, S. (2001). Judgment under emotional certainty and uncertainty: The effects of specific emotions on information processing. *Journal of Personality and Social Psychology*, 81, 973-988.
- Wason, P. & Johnson-Laird, P. (1972). *Psychology of reasoning: structure and content*. Oxford, England: Harvard University Press.

Appendix A

	Topics	In this section, please rate how strong YOUR opinions are for the following topics:					In this section, please rate how strong you believe OTHER college students opinions are for the following topics:				
		No opinion				Strong opinion	No opinion				Strong opinion
1.	Partisan Politics (e.g. Are news stations such as Fox News, or hosts such as Glen Beck out of line?)	1	2	3	4	5	1	2	3	4	5
2.	Heating and Air conditioning Costs (e.g. Are they too expensive in Columbus?)	1	2	3	4	5	1	2	3	4	5
3.	Homosexuality (i.e. "Don't ask, don't tell")	1	2	3	4	5	1	2	3	4	5
4.	The best Spring Break Destinations (Florida vs. Cancun Mexico)	1	2	3	4	5	1	2	3	4	5
5.	Environmental Activism (global warming)	1	2	3	4	5	1	2	3	4	5
6.	Gun Control/rights (e.g. concealed carry laws)	1	2	3	4	5	1	2	3	4	5
7.	Coffee Consumption (e.g. hazards, health benefits, ect.)	1	2	3	4	5	1	2	3	4	5
8.	Affirmative Action (Is it fair/ should it be used?)	1	2	3	4	5	1	2	3	4	5
9.	The weather (Does Columbus get too much snow?)	1	2	3	4	5	1	2	3	4	5
10.	Drug Regulation (e.g. legalization of marijuana)	1	2	3	4	5	1	2	3	4	5
11.	Presidential Personal Discretionary Spending (i.e. Does Michelle Obama spend too much on clothes, should she?)	1	2	3	4	5	1	2	3	4	5
12.	Should Creationism be taught in public schools/ prayer in schools?	1	2	3	4	5	1	2	3	4	5
13.	Healthcare (Is the reform bill good or bad? Is more needed?)	1	2	3	4	5	1	2	3	4	5
14.	Capital Punishment (Should it be used/ when?)	1	2	3	4	5	1	2	3	4	5
15.	Abortion (e.g. Stem cell research, pro - choice vs. pro-life)	1	2	3	4	5	1	2	3	4	5

16.	Tourism in Iceland (Is it a nice place to visit?)	1	2	3	4	5		1	2	3	4	5
17.	The price of groceries (Are food costs too high?)	1	2	3	4	5		1	2	3	4	5
18.	Immigration Issues (Should illegal immigrants be naturalized/ sent back?)	1	2	3	4	5		1	2	3	4	5
19.	Summer Internship Opportunities (Are there enough offered?)	1	2	3	4	5		1	2	3	4	5
20.	Cloning/Genetic Engineering (GMOs, are they safe? Should cloning be allowed?)	1	2	3	4	5		1	2	3	4	5
21.	Alcohol Abuse/ Laws (e.g. lowering the drinking age)	1	2	3	4	5		1	2	3	4	5
22.	The legal age to marry (Is it too high/low, do we need it?)	1	2	3	4	5		1	2	3	4	5
23.	Torture (i.e. should it be allowed?)	1	2	3	4	5		1	2	3	4	5
24.	The Best/Worst hairstyles (How much does a person's hairstyle affect your perception of them?)	1	2	3	4	5		1	2	3	4	5
25.	Euthanasia/ Dr. Assisted Suicide (Should it be allowed?)	1	2	3	4	5		1	2	3	4	5
26.	Obesity Epidemic (Is there a crisis, should we pass laws controlling what people eat?)	1	2	3	4	5		1	2	3	4	5
27.	Gay marriage (Should marriage be available to both homosexual and heterosexual couples?)	1	2	3	4	5		1	2	3	4	5

Appendix B

Emotional Paragraphs:

Same-sex Marriage

The debate over whether homosexual couples should be allowed to marry and assume the full rights, privileges, and protections of such a union has led to conflict and desires to revise legislation. Many countries such as Portugal, Spain, the Netherlands, and Norway have legalized same sex marriage. However, in the United States same-sex marriage is legal in only a few states including Connecticut, Iowa, Massachusetts, New Hampshire, and Vermont. Opponents to legalization of such marriages argue that the definition of a marriage should be limited only to the union of a man and a woman. Some believe that same-sex unions are immoral, unnatural, and have social consequences of undermining traditional family values and the institution of marriage. On the other hand, proponents of legalization of same-sex marriages argue that same-sex couples are entitled to full legal and social rights and benefits that married heterosexual couples have including Social Security benefits, veterans' benefits, health insurance, Medicaid, hospital visitation, estate taxes, retirement savings, pensions, family leave, and immigration law. ***Some believe that legalizing such unions will normalize and legitimize same-sex relationships which will promote family values, making gay parents better parents than many heterosexual parents. Financial, psychological, and physical well-being are enhanced by marriage.*** Children of same-sex couples benefit from being raised by two parents within a legally-recognized union supported by society's institutions. The issue of same-sex marriage has been a focus of considerable political debate. While states, including Ohio, have banned same-sex marriages, there is growing support from public figures such as Barney Frank to repeal of the 1996 Defense of Marriage Act. Repealing this act would be a step toward the federal government extending the rights and privileges of couples in heterosexual marriages to those in same-sex marriages.

Abortion

The debate over whether a woman should have the right to an abortion (pro-choice) or be barred from terminating another life (pro-life) has led to a great deal of debate, anger and emotional disputes in the United States. Since the controversial decision of Roe vs. Wade, which struck down state laws banning abortion in 1973, various regulations from requiring parental involvement to restricting late-term abortion have emerged as the federal government has failed to establish national regulation. The ethical debate of abortion usually surrounds whether or not the fetus has rights, such as the right to life, and if the pregnant woman's rights over her own body give her a right to an abortion regardless of the fetuses' right to life. They also argue that forcing a woman made pregnant in a violent act such as rape or incest to have the baby would cause further psychological harm to the victim. Proponents argue a woman has the right to control her own body and that during the first trimester the fetus is not yet a human being as it cannot exist independent of the mother, while pro-life supporters argue that abortion is morally wrong because the fetus is a potential life with its own rights, equating abortion with manslaughter. Regardless, many Americans firmly believe that abortion is immoral and should be illegal in all cases, including rape and incest. ***Some "pro-life" supporters argue that the mother's rights do not trump the baby's rights and therefore all abortions should be banned, even in situations where the mother will die if the abortion does not take place.*** Citing religious doctrine, moral obligations and legal proceedings such as Gonzalez vs. Carhart (upholding the Partial Birth Abortion Ban), groups across the country continue to press for national legislation banning all abortions. Currently, in the United States, only 32% of people respondents believe abortion should be legal in all circumstances, but pro-life supporters say that number is quickly changing. The debate continues to incite Americans and plays an ever increasing role in determining the outcome of US political elections.

Healthcare

Health care reform has been topic of intense political debate in the United States for decades. Reform has focused on issues of increasing coverage, decreasing social and financial burdens, and reforming insurance and healthcare industries. After many protests and demonstrations, extensive lobbying in Washington and fierce debate across the country, President Barack Obama signed the Healthcare Reform Bill in March of 2010. Passage of this bill will result in striking changes to the U.S. healthcare system, including guaranteed coverage for children with pre-existing conditions, no lifetime limits on benefits received, and inability for an insurer to deny claims without a chance for appeal. However, not everyone is happy with the bill. There are many who believe that the bill does not provide enough reform, leaving many people with little or no healthcare coverage. They argue adequate healthcare is a basic right which should be guaranteed by the government and point to Social Security and Medicare as successful and well-liked government programs. At the same time, many are opposed to the bill because they believe that there should be minimal government intervention in the healthcare system. They also fear high costs for the taxpayer. Opponents have called such legislation a government takeover of healthcare; they argue that this is a big step toward a socialist system which will result in low quality healthcare and long waiting times for treatment for everyone. In addition, they argue that individuals will have limited choices for healthcare plans, personal doctors, and other medical services. ***Some opponents who believe in a minimal role for government in healthcare argue that the United States is on a slippery slope in which big government will invade individual privacy and monitor lifestyle choices, denying coverage to people who smoke, drive too fast, have an unhealthy body mass index (BMI), consume fast food more than once per month, and drink more than 8 ounces of sugary beverages per week.*** How happy the public will be with the healthcare changes will be seen as time passes. What is known is that after decades of failed attempts at reform, a bill has been passed which does provide coverage to an estimated 30 million people who lacked it and does regulate private insurers more closely.

Neutral Paragraphs:

The Legal Age to Marry

The legal age at which a man and women can marry has changed over time, as has the perceived “proper age” at which to be married. While the age at which many women in the United States marry has continued to increase, the age at which they can become legally entwined has remained 18 without parental consent (with the exception of Nebraska, where you have to be 19). While some states allow pregnant teenagers or those who already have a child to get married without parental consent, most couples must still have the approval of court, especially if they are under 16. Supporters of current marriage laws point out that the brain at age 16 is not yet fully developed. Younger couples, they claim, lack not only experience living on their own, but may be unable to handle the fiscal responsibilities, let alone the stress that comes with marriage and children. Many feel that earlier marriages will end in divorce and increase marital strife; they claim that “children” at the age of sixteen are not prepared to take on a spousal role. On the other hand, some argue that setting the age limit at 18 is unreasonable, pointing to the fact that traditionally, women were given in marriage at extremely young ages, sometimes as young as 13 and 14 years. They claim such a high age requirement it is an infringement and burden on an individual’s rights. A growing number of young Americans believe that men and women should be able to be legally married at the age of 16, and are pushing for federal legislation to remove parental restrictions before age 18. ***Some who advocate lowering the required age to marry believe younger married couples are better able to understand their children, form more lasting relationships, and will be better parents than older couples; and so by lowering the legal age to 16, we can revitalize the broken American family.*** However, while biologically men and women may be prepared to procreate at such a young age, the continued delayed age of marriage in older adults, and the constraints of our culture suggest that Americans at such a young age may still not be psychologically prepared for the rigors of

marriage. For now, the legal age remains 18, but that may change as our culture continually evolves and expands its beliefs of accepted traditions and values.

The Best/Worst Hairstyles

From the bob to the mullet, to “bowl” cuts, crimped hair and side ponytails, hair styles have changed dynamically through the ages. However, one thing has stayed the same; hairstyles continue to dominate our first impressions and opinions of other, for better or for worse. Many psychologists have lent considerable discussion to the concept, studying how Westerners define and redefine themselves through hairstyle choice. They claim that the neatness, cleanliness, style and appropriateness of a hairstyle to a situation can be a make or break point for interviews, arguments and first impressions. While many continue to spend hours each day laboring to make their hair appropriate for their chosen activity or lifestyle, others believe hairstyle plays no role in others impression. They claim that while it may initially drive a person’s thoughts one way or another, the substance of the subsequent conversations and actions will dominate, and thus radical hairstyles should be prohibited in the workplace. For example, the Cleveland Clinic’s rules stipulate that hair must be clean, non-aromatic, and of a “natural color,” as excessive attention with hairstyle is a burden on its employees and may be bothersome to its patients. Others in favor of regulation point out that lack of regulation may lead to health concerns; unkempt hair can carry germs and viruses that can be spread when hair or other adornments fall into food. On the other hand, opponents of hairstyle regulation feel that such laws are a form of oppression, taking away the employee’s right to freely express their style. They argue that employees should be allowed to wear their hair however they choose, and believe that expressing their style through hairstyle choice does not decrease work productivity or increase health risks. ***Some activists opposed to regulation of hairstyles believe that hair nets and hats worn by employees to prevent contamination of food infringe on their first amendment rights, and that any such apparatus should be banned.*** Naturally, few employers are interested in repealing such rules as they fear a possible loss in sales or integrity of their workplace standards. Nonetheless, the debate continues over the weight a hairstyle lends to a person’s perception of others, and how it affects their and others behavior.

The Best Spring Break Destinations (Florida vs. Cancun Mexico)

Each year thousands of college and high school students alike flock to the beaches of Florida and Cancun to enjoy their spring break, yet the debate continues as to which location has the most to offer. Students who habitually return to the same vacation spot each year are fiercely defensive in asserting the claim that they have the best spot, yet both locals seem equally popular among vacationers. Floridians cite pristine white sand beaches, some of the best snorkeling in the world and the safety and security that comes with America. Supporters of Cancun cite the draw of a foreign country, tours to ruins such as Chichen Itza, wild and crazy night life and a plethora of bars and night clubs. With cheap prices, copious and easily accessible alcohol and some of the most magnificent historic ruins in the world, pro-Cancun tourists argue Cancun is the best spring break spot. Many pro-Florida supporters, however, believe that the recent dangers due to drug smuggling and police raids leave Cancun out of the question, and feel that the substandard offerings in Mexico, along with the risk, can’t even compare with the benefits of a Florida vacation. They point out that a trip to Florida requires no passport, exchange of currency or risk of sickness or disease from drinking the water. Florida, they claim, offers everything Cancun does, but in a safer environment; Visitors to the Sunshine State can immerse themselves in the history of beautiful St. Augustine, or hit the safe, clean beaches surrounding the state while supporting U.S. tourism. ***Thus, some pro-Florida tourists want to ban travel to Cancun for any person under the age to 21, due to the high number of deaths and risks of unsupervised drinking in a foreign country.*** Pro-Cancun supporters are opposed to such bans, arguing that such dangers are prevalent everywhere and that travel bans are useless, and will only serving to cripple the tourism industries in the fledgling country. Currently, none of the U.S.

State Legislatures are considering such legislation, but many political and other local groups have supported and sent such legislation to congress. For example, a group, Moms Against Alcohol Violence (MAAV) has been canvassing Senator Bill Nelson of Florida to create such legislation. In several Southern states, similar legislation surrounding the crackdown on drugs in Mexico have also been proposed. For now, both Florida and Cancun remain viable options for a spring break vacation, though which one is the best remains a tossup.

Appendix C

Sample Questions:

Emotional Example: Abortion

1. The passage was about whether the Supreme Court overstepped its bounds in the Roe vs. Wade decision?
Choose: True False
2. Which of the following was not stated in the passage:
Choose: a. Roe vs. Wade struck down state laws banning abortion in 1973
 b. Many women who have had an abortion regret their decision later.
 c. 32% of U.S. citizens say abortion should be legal in all situations
 d. The ethical debate of abortion usually surrounds whether or not the fetus has rights.
3. **According to the passage, all “pro-life” supporters believe that abortion should be illegal in all cases, even if the mother will die if the abortion does not take place?**
Choose: YES NO
4. In the passage, which was not mentioned as argument supporting the “pro-choice” argument?
Choose: a. “age” of the fetus
 b. woman’s rights to her body
 c. psychological harm
 d. civil rights laws
5. **According to the passage, is it possible that some pro-choice supporters believe that women should be able to have an abortion in the case of rape or incest?**
Choose: YES NO

Neutral Example: The Legal Age to Marry

1. The passage was about whether or not we should lower the legal age to marry in the United States?
Choose: True False
2. Which of the following *was* stated in the passage:
Choose: a. pregnant teenagers never need parental consent to marry
 b. Nebraska is the only state where you need parental consent to marry until age 19
 c. Younger marriages occur more often in the Southern U.S.
 d. federal legislation is in congress to reduce the legal age to marry to 16
3. **According to the passage, all advocates of lowering the legal age to marry believe that younger couples are better able to understand their children and will make better parents than older couples?**
Choose: YES NO
4. In the passage, which was not mentioned as an argument in favor of younger marriages?
Choose: a. biological evidence

- b. historical tradition of young marriages
- c. burden on individual rights
- d. statistics on healthier births from younger mother

5. According to the passage, is it possible that there are people who advocate lowering the age to marry but do not believe that younger adults will make better parents?

Choose: YES NO

Appendix D

Sample Sentences:

Neutral: Skiers

- 1.) All snowboarders are Shaun White fans.
- 2.) Some snowboarders are Shaun White fans.
- 3.) No snowboarders are Shaun White fans.
- 4.) Some snowboarders are not Shaun White Fans.

Books

- 1.) All books are intellectual stimulation.
- 2.) Some books are intellectual stimulation.
- 3.) No books are a intellectual stimulation.
- 4.) Some books are not intellectual stimulation.

Emotional (Topic): Abortion

- 1.) All pro-choice supporters are democrats.
- 2.) Some pro-choice supporters are democrats.
- 3.) No pro-choice supporters are democrats.
- 4.) Some pro-choice supporters are not democrats.

Gay Marriage

- 1.) All young college students are gay marriage supporters.
- 2.) Some young college students are gay marriage supporters.
- 3.) No young college students are gay marriage supporters.
- 4.) Some young college students are not gay marriage supporters.

Emotional (Surprise): Asians

- 1.) All Asians are redheads.
- 2.) Some Asians are redheads.
- 3.) No Asians are redheads.
- 4.) Some Asians are not redheads.

French Fries

- 1.) All French fries are a healthy food.
- 2.) Some French fries are a healthy food.
- 3.) No French fries are a healthy food.
- 4.) Some French fries are not a healthy food.